Title:	Shipboard test review of DESMI Ocean Guard Ballast Water Treatment System as per IMO Resolution MEPC174.(58)
Client:	DESMI Ocean Guard AS
Prepared by:	London Design Support Office, London
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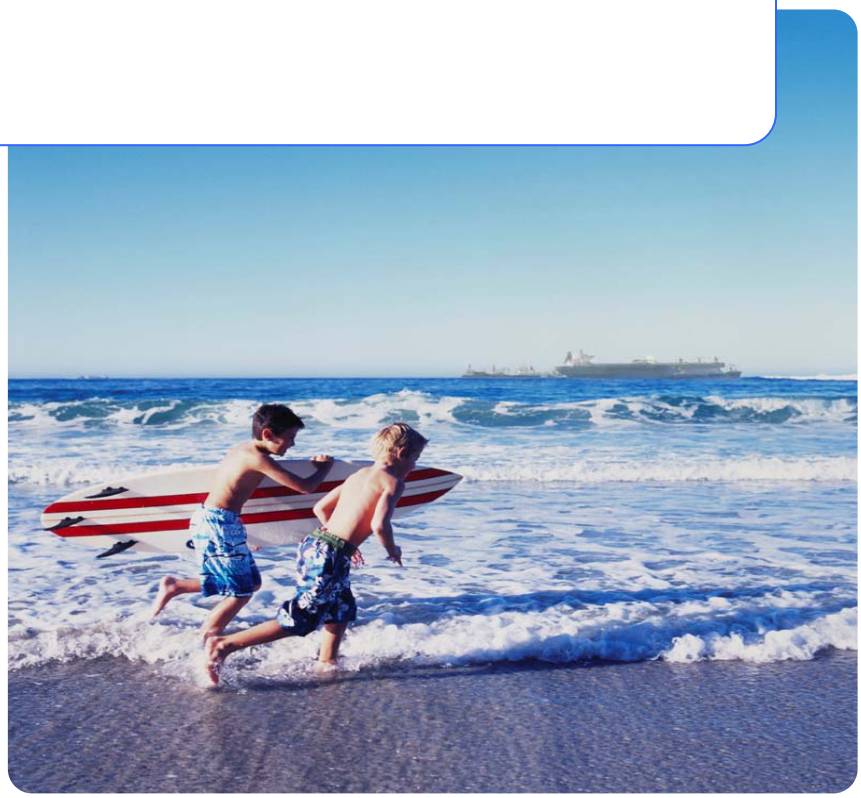

Lloyd's Register

Contents

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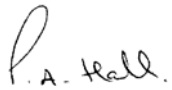
Peter Hall Manager Engineering Systems & Marpol London Design Support Office Lloyd's Register EMEA,London	
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1. Introduction

The purpose of this report is to evaluate the shipboard tests and confirm if the DESMI Ocean Guard Ballast Water Management System DOG P40-300 meets the performance standards of Regulation D-2 of the "International Convention for the Control and Management of Ships' Ballast Water and Sediments".

This report also assesses whether the test procedures and sampling regimes have been followed in accordance with IMO G8 Guidelines (2008). Any deviations from the IMO G8 Guidelines, and the reasons given within the DESMI Performance Evaluation Report, have been duly noted and evaluated.

2. DESMI Ocean Guard Ballast Water Management System DOG P40-300

The DESMI Ocean Guard BWMS DOG P40-300 combines mechanical (filtration), physical (UV disinfection) and chemical (ozone[1]) treatments. This three-stage system includes:

[1] Incoming ballast water passes through a pressurised filter (pore size: 40 microns for the DOG P40-300) typically installed after the ballast pump in the piping layout.

[2] After the filter, incoming ballast water flows through a UV reactor which exposes the water to a high dose of UVC irradiation from low pressure UV lamps. During this process the reactor also generates ozone, used in the final stage of treatment as described in [3].

[3] Water passes a venturi injector unit in the piping system that injects fully mixed ozone and air into the water flow. Gaseous ozone diffuses into the water and reacts with any organisms. The ozone concentration reduces to zero shortly after injection (because of the low concentration (0.2 mg/l) produced).

During de-ballasting the water flows through the last two stages of the BWMS only, bypassing the filter section.

3. Table of Adherence with IMO G8 Guidelines and any Deviations

Table 1 gives details of compliance with ANNEX: PART 2 – Test and Performance Specifications for Approval of Ballast Water Management Systems of the IMO G8 Guidelines, including comments and any deviations.

[1] Ozone is classed as an active substance under IMO G9 Guidelines. An "Active Substance" means a substance or organism, including a virus or a fungus that has a general or specific action on or against harmful aquatic organisms and pathogens. Note: The use of an active substance will be assessed in a separate land-based report.

3.1. Shipboard tests

Requirement	Sub-Requirement	Compliance with IMO G8 (Yes/No)	Comments	Any Deviations
2.2.1 Shipboard Test Cycles		Yes		
2.2.2 Success Criteria	1. Provision of Test plan	Yes	See "References": QMP & QAPP in DESMI Performance Evaluation Report	
	2. Provision of Treatment Rated Capacity documentation	Yes	See "Technical Description", QAPP, Appendix A in DESMI Performance Evaluation Report	
	3. Test cycle Treatment Rated Capacity	Yes	Treatment Rated Capacity is determined by the ship's ballast pump capacity. The system used in the Shipboard Trials – 300m^3/hr.	
	4. Documentation of the results for three consecutive valid test cycles	Yes	Evidence provided in DESMI Performance Evaluation Report Tables 6.1, 6.2, 6.3, 6.4, 6.5	
	5. Viable organism concentration for uptake water (control/treated), and control tank discharge	Yes	See DESMI Performance Evaluation Report, Tables 6.3, 6.4, 6.5	
	6. Sampling regime	Yes	See DESMI Performance Evaluation Report, 5.2 Sampling, and Table 5.2. Sample size volumes are complied with.	Note: Samples for organisms ≥ 50µm were collected by continuous flow rather than beginning, middle and end of uptake/discharge. This is justified within the report.
	7. Test cycles (G8 requires trial period not less than 6	Yes	Test period from September 2011 to April 2012.	

Requirement	Sub-Requirement	Compliance with IMO G8 (Yes/No)	Comments	Any Deviations
	months)			
	8. Three consecutive test cycles – validity	Yes	DESMI Performance Evaluation Report, p.4	
	9. Source water physical components	Yes	See DESMI Performance Evaluation Report, Tables 6.1, 6.2	
	10. Additional info (1-6)	Additional info to be confirmed	10.1 Locations of uptake and discharge are stated in Table 5.1, p.4 of the DESMI Performance Evaluation Report	

Table 1: Compliance with Annex of the IMO G8 Guidelines

4. DESMI Ocean Guard Ballast Water Management System DOG P40-300 compliance with D-2 performance requirements

D-2 Regulation stipulates that ships meeting the requirements of the Convention by meeting the ballast water performance standard must discharge:

less than 10 viable organisms per cubic metre greater than or equal to 50 micrometres in minimum dimension;

Ship-based testing results meet the Standard D-2 (yes/no)	Land-based testing	Pass D-2 (yes/no)
Yes		

less than 10 viable organisms per millilitre less than 50 micrometres in minimum dimension and greater than or equal to 10 micrometres in minimum dimension; and

Ship-based testing results meet the Standard D-2 (yes/no)	Land-based testing	Pass D-2 (yes/no)
Yes		

less than the following concentrations of indicator microbes, as a human health standard:

Toxicogenic Vibrio cholerae (serotypes O1 and O139) with less than 1 Colony Forming Unit (cfu) per 100 millilitres or less than 1 cfu per 1 gramme (wet weight) of zooplankton samples;

Ship-based testing results meet the Standard D-2 (yes/no)	Land-based testing	Pass D-2 (yes/no)
Yes		

Escherichia coli less than 250 cfu per 100 millilitres; and

Ship-based testing results meet the Standard D-2 (yes/no)	Land-based testing	Pass D-2 (yes/no)
Yes		

Intestinal Enterococci less than 100 cfu per 100 millilitres.

Ship-based testing results meet the Standard D-2 (yes/no)	Land-based testing	Pass D-2 (yes/no)
Yes		

5. DESMI Ocean Guard Ballast Water Management System DOG P40-300 compliance with D-2 performance requirements

D-2 Regulation stipulates that ships meeting the requirements of the Convention by meeting the ballast water performance standard must discharge:

less than 10 viable organisms per cubic metre greater than or equal to 50 micrometres in minimum dimension;

Ship-based testing results meet the Standard D-2 (yes/no)	Land-based testing	Pass D-2 (yes/no)
Yes		

less than 10 viable organisms per millilitre less than 50 micrometres in minimum dimension and greater than or equal to 10 micrometres in minimum dimension; and

Ship-based testing results meet the Standard D-2 (yes/no)	Land-based testing	Pass D-2 (yes/no)
Yes		

less than the following concentrations of indicator microbes, as a human health standard:

Toxicogenic Vibrio cholerae (serotypes O1 and O139) with less than 1 Colony Forming Unit (cfu) per 100 millilitres or less than 1 cfu per 1 gramme (wet weight) of zooplankton samples;

Ship-based testing results meet the Standard D-2 (yes/no)	Land-based testing	Pass D-2 (yes/no)
Yes		

Escherichia coli less than 250 cfu per 100 millilitres; and

Ship-based testing results meet the Standard D-2 (yes/no)	Land-based testing	Pass D-2 (yes/no)
Yes		

Intestinal Enterococci less than 100 cfu per 100 millilitres.

Ship-based testing results meet the Standard D-2 (yes/no)	Land-based testing	Pass D-2 (yes/no)
Yes		

5.1.1. Uptake Water

Control Tank

	Trial 1	Trial 2	Trial 3	Average
Organisms >50 µm [counts/m^3]	4892	8199	9983	7691

Organisms 10-50 µm [counts/mL]	>150	>160	54	-
E. coli [cfu/mL]	<10	130	<10	-
Enterococci [cfu/mL]	120	21	<10	-
Vibrio cholera [cfu/mL]	<1	<1	<1	-

Table 2: Average Shipboard Test Results for Uptake Water – Control Tank

5.1.2. Discharge Water

Control Tank

	Trial 1	Trial 2	Trial 3	Average
Organisms >50 µm [counts/m^3]	579	2010	1347	1312
Organisms 10-50 µm [counts/mL]	>160	>160	46	-
E. coli [cfu/mL]	800	14	<10	-
Enterococci [cfu/mL]	280	<10	<10	-
Vibrio cholera [cfu/mL]	<1	<1	<1	-

Table 3: Average Shipboard Test Results for Discharge Water – Control Tank

Treated Tank

	Trial 1	Trial 2	Trial 3	Average
Organisms >50 µm [counts/m3]	0.17	0.26	0	0.14
Organisms 10-50 µm [counts/mL]	<0.18	<0.18	<0.18	-
E. coli [cfu/mL]	<10	<10	<10	-
Enterococci [cfu/mL]	<10	<10	<10	-
Vibrio cholera [cfu/mL]	<1	<1	<1	-

Table 4: Average Shipboard Test Results for Discharge Water – Treated Tank

"-" denotes that an average cannot be calculated.

Data to populate the above three tables has been taken from within Tables 6.3, 6.4 and 6.5 from the DESMI Performance Evaluation Report.

6. Conclusion

The DESMI Ocean Guard Ballast Water Management System DOG P40-300 shipboard test results meet the performance standards of Regulation D-2 of the "International Convention for the Control and Management of Ships' Ballast Water and Sediments".

According to the DESMI Performance Evaluation Report, shipboard test procedures and sampling regimes have been mostly followed in accordance with IMO G8 Guidelines.

The only deviation noted (and not noted within Table 1) concerns a requirement in the Quality Assurance Project Plan, Section 9.4.1 regarding the temperature of water samples in storage onboard, after collection and prior to processing. Objective stated as 1 - 10°C. Actual temperatures prior to processing were 10 -14°C, due to ambient water temperatures of 19.5 - 21.1°C. Deviation not considered relevant.

Appendix C: Filtration fineness of the present DESMI Ocean Guard Ballast Water Treatment System within the DESMI Performance Evaluation Report includes a letter about the change in filtration mesh size. The DOG P40-300 should have a mesh size of 40 microns, but it seems that this was changed to 30 microns during the course of the shipboard testing. This issue doesn't change the fact that D-2 Regulation performance standards were met. Clarification may be required to support this.

7. References

1. Guidelines for Approval of Ballast Water Management Systems (G8). Resolution MEPC.174 (58), adopted on 10 October 2008.

2. Procedure for Approval of Ballast water Management Systems That Make Use of Active Substances (G9). Resolution MEPC.169 (57), adopted on 4 April 2008.

3. Performance Evaluation in Shipboard Test of the DESMI Ocean Guard BWMS DOG P40-300, June, 2012. (Final Report) for Type Approval according to Regulation D-2 and the relevant IMO Guideline (G8) (Shipboard tests carried out from September, 2011 through April, 2012)

4. Quality Management Plan (QMP), Version 2.3, 7.9.2011, with any listed Amendments/Deviations.

5. Quality Assurance Project Plan (QAPP) (revised) for Shipboard Tests of DOG P40-300 Ballast Water Management System, 9.9.2011

Appendix

Desmi Ocean Guard letter to Lloyd's Register EMEA

To: Lloyds Register, Att.: Mr. Ubong
From: DESMI Ocean Guard with assistance from Senior Biologist Gitte Petersen, DHI
Date: October 10th 2012

Subject: Review of Shipboard- and Landbased Tests

Questions rose for Shipboard test:
Filter fineness have been changed.

Reply:
Enclosed this reply please find a document issued by Bollfilter and DESMI Ocean Guard regarding change of filter fineness. It is stating that DESMI Ocean Guard changed fineness from 40 micron to 30 micron prior to the actual land based test as well as shipboard test.

Lloyds Register, in the name of Mr. Martin Schabert witnessed the filter placed at the shipboard test container after return to Aalborg, Denmark in order to see whether the filter was 30 micron.

Questions rose for Land based test:
Main issues are twofold:

- Is MPN an acceptable methodology to enumerate phytoplankton?
- Test cycle D does not meet the D2 requirements.

Regarding MPN please consult chapter 3.3.4.2 at the DHI test report. Following statement is said in the report:
"The phytoplankton regrowth assay (MPN) was consolidated by identification, to the level of taxa or species, of algae that were present in the inlet water and algae that were able to grow under the conditions applied in the phytoplankton regrowth assay. The combination of ^{14}C incorporation and the re-growth assay provides a more reliable estimate of truly viable phytoplankton as none of these methods is affected by the delayed effect of the UV treatment".

Also see chapter 3.4.3.2:
"The densities of live organisms in the 4 size class ≥ 10 and < 50 µm in the treated discharge water were consistently below 10 organisms/mL when determined by using the re-growth assay. The enumeration of algae by use of the re-growth assay is directly related to growth, and the values obtained were supported by a substantial reduction of the primary production (Table 3.15)".

In layman term: As low pressure UV treatment is a "soft killer" by destroying the DNA string and not actually instantly killing the organisms, determination of re-growth is considered the more correct way of determine whether the organism are "non viable" after treatment. Non viable does not mean "dead".

Re-growth assays by use of MPN methodology is also used by other test institutes for enumerate phytoplankton.

Regarding Test Cycle D, this test does very correctly not meet the D2 requirements. The number of algae was 0.2 /mL, but the number of zoo-plankton were 30/m³. This was due to a leakage in our piping system which was repaired after the results were released from the test institute (DHI).

The reason for including test Cycle D was due to the fact that as a G9 system (including active substances) a number of chemical analysis should be submitted to GESAMP (IMO Expert Group

evaluation all G9 systems). In theory only one set of analysis (representing one test cycle) is according to the G9 guideline sufficient. However, to obtain robust data DESMI Ocean Guard and DHI decided to obtain data (WET test data and measurements of DBP (disinfection by-products) from 4 test cycles (two set of data for each salinity tested).

From a pure G8 point of view, test cycle D is to be regarded as a failed test and was therefore repeated.

TBC related to Land Based Tests will be commented in a separate document from DHI, Senior Biologist Ms. Gitte Petersen

DESMI Ocean Guard A/S
- ballast water treatment systems

Lloyds Register EMEA
Strandvejen 104A
2900 Hellerup

January 5th, 2012

Att.: Mr. Martin Schabert

Subject: Filtration fineness at DESMI Ocean Guard present Ballast Water Treatment System

Dear Mr. Schabert,

Below please find a combined statement from BOLLFILTER Nordic and DESMI Ocean Guard regarding the filtration mesh size at the present DESMI Ocean Guard Ballast Water Treatment System. This statement is giving information about when and why the changes in mesh size took place.

First of all it should be emphasized that the main reason for confusion about the mesh size used is DESMI Ocean Guard. The main reason for not giving the change in mesh size the required attention was simply lack of awareness about the importance of this issue. From DESMI Ocean Guard point of view we considered the main issue to be that we used the same filtration technology during the time of testing the system, even the same manufacturer of filters and actually also the same type of filter for both land based and shipboard testing.

DESMI Ocean Guard also had the maybe wrong understanding that as long the filtration technology and the filtration supplier was the same it was acceptable to implement the constant improvement of technologies available. It would of course be critical to jump from 40 micron to 50 micron filter mesh. But immediately utilizing an improved filtration opportunity like going from 40 micron to 30 micron was from DESMI Ocean Guard's point of view a natural decision.

The filter used at the DESMI Ocean Guard BWTS is BOLLFILTER type 6.18.2. When the first filter was delivered in February 2010 the present mesh size available was 40 micron. It should be mentioned that the filter housing itself does not require any modification for using 30 micron and 40 micron mesh size respectively. During the testing period in the summer 2010 DESMI Ocean Guard realized various problems with the system, especially in Fresh Water. Also the filter performance was considered a little critical from DESMI Ocean Guard's point of view.

A lot of initiatives were taken during this period; one of the initiatives was a delivery of a complete set of 30 micron mesh filter elements for the existing filter in Hundested. The 30 micron filter elements were delivered free of charge from BOLLFILTER Nordic to DESMI Ocean Guard in November 2010.

BOLLFILTER Nordic has been assisting with filter inspection and service quite frequently during the test period going from March 2011 to August 2011. DESMI Ocean Guard has independently made inspection and servicing on the filter as well. The 30 micron filter elements have been mounted in the filter from the start of actual test cycle starting March 2011.

With regard to the filter used at the shipboard test system the reason for confusion is again DESMI Ocean Guard. The actual purchase of the filter was arranged by the company DESMI A/S, one of the DESMI Ocean Guard shareholders. DESMI Ocean Guard had not informed DESMI A/S about the change of mesh size, so it was from DESMI A/S assumed that it was a 40 micron mesh size required for the test. Verbal correspondence between DESMI Ocean Guard A/S and BOLLFILTER Nordic at a

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later stage of the delivery time (at that time 12 weeks) clarified that the filter elements should of course be the same quality as the filter elements used in Hundested. So the filter was actually equipped with 30 micron filter elements and additional 5 spare elements all of 30 micron quality. But due to the misunderstandings at the actual time of ordering the filter became marked as a 40 micron filter. DESMI Ocean Guard and BOLLFILTER Nordic will arrange that this wrong labeling of the filter will be changed to the correct 30 micron in January 2012.

DESMI Ocean Guard does solely take the responsibility of this confusion about the mesh size. However, the filter elements used for all the tests giving a valid land based test and so far 2 out of 3 valid shipboard tests are 30 micron.

DESMI Ocean Guard will still emphasize that being restricted in immediately utilizing technology improvements seems not logic. But this can be discussed at another stage.

We do hope the above statement will satisfy Lloyds Register, and both DESMI Ocean Guard and BOLLFILTER Nordic will of course assist in case there should be any questions to the above.

Yours sincerely

BOLLFILTER Nordic

Robert Jellinggaard

DESMI Ocean Guard

Christian Ingvorsen

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